ADI Solutions for Industrial Equipment Battery Charging

2023/5/9

DFAE: Boris Wang

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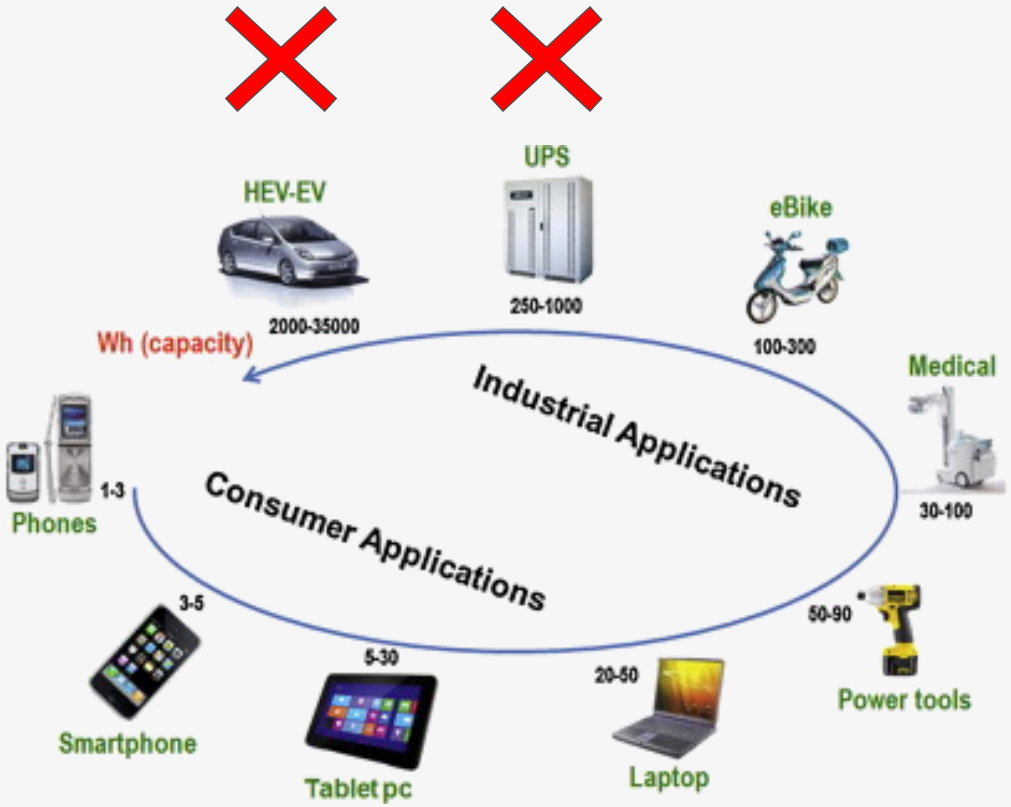
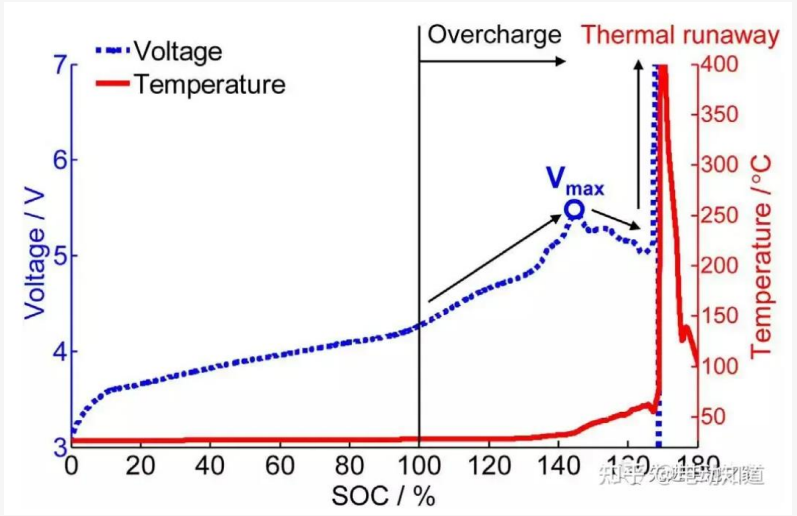
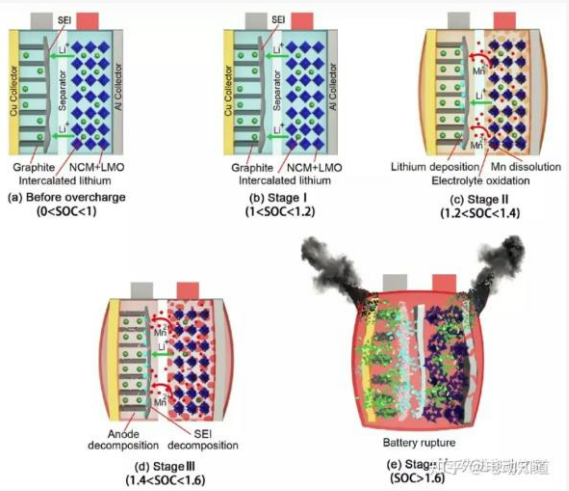
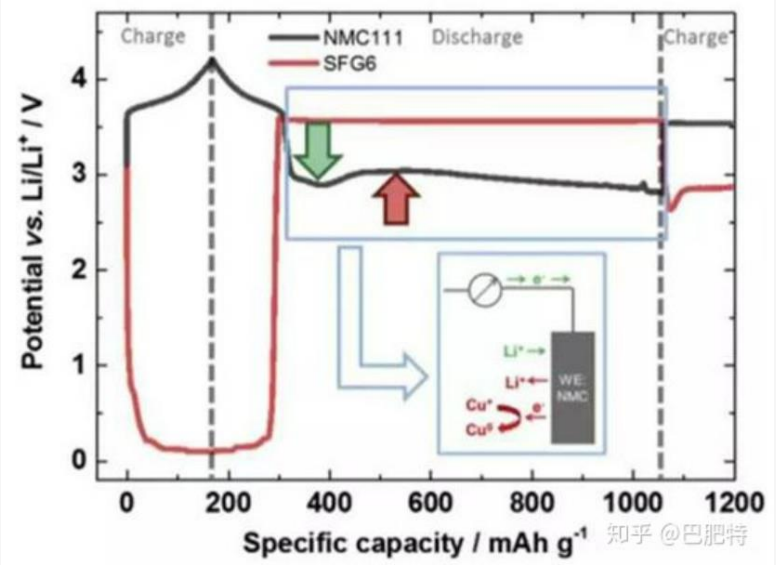
Battery Applications







锂电池的过充（热失效）



锂电池的过放

Battery Chemistries Pros/Cons

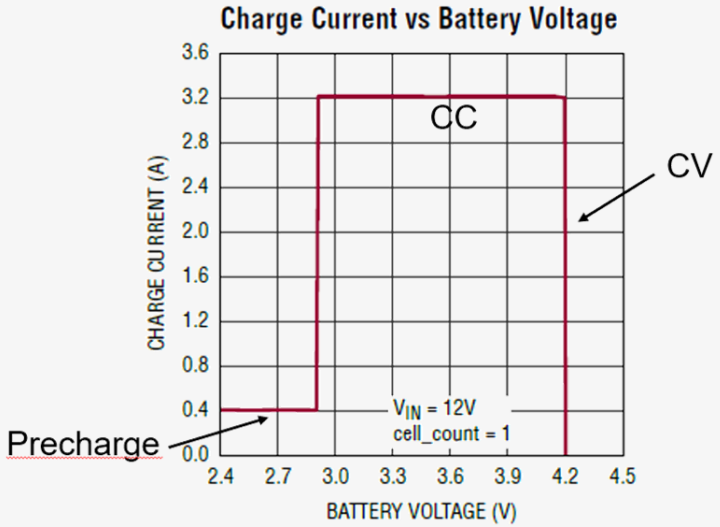
- **Li-Ion/Li-polymer:** High cycle count, high specific energy. Needs protection circuitry and handling care.
- **Pb Acid:** Very Mature, rugged, economical. Low specific energy, limited cycle count, lead is toxic
- **NiCd:** Long service life, well understood, high discharge currents, extreme temperatures, rugged, ultra-fast charging with minimal stress. Not environmentally friendly
- **NiMH:** Replaces NiCd with only mildly toxic metals, higher specific energy, many medical, industrial and consumer applications. Low cell voltage, high self-discharge.
- **LiFePO4:** High charge/discharge rate, very high cycle count. Lower specific energy, lower charge voltage vs. Li-Ion

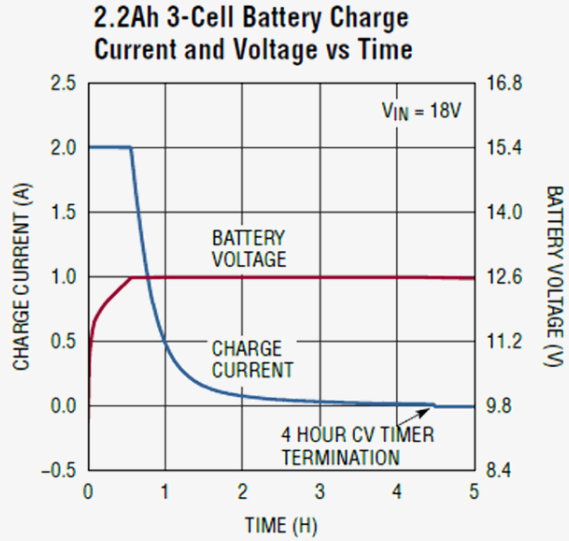
Specifications	Lead Acid	NiCd	NiMH	Li-ion[1] Cobalt	Li-ion[1] Manganese	Li-ion[1] Phosphate
Specific energy (Wh/kg)	30–50	45–80	60–120	150–250	100–150	90–120
Internal resistance	Very Low	Very low	Low	Moderate	Low	Very low
Cycle life[2] (80% DoD)	200–300	1,000[3]	300–500[3]	500–1,000	500–1,000	1,000–2,000
Charge time[4]	8–16h	1–2h	2–4h	2–4h	1–2h	1–2h
Overcharge tolerance	High	Moderate	Low	Low. No trickle charge		
Self-discharge/ month (room temp)	5%	20%[5]	30%[5]	<5% Protection circuit consumes 3%/month		
Cell voltage (nominal)	2V	1.2V[6]	1.2V[6]	3.6V[7]	3.7V[7]	3.2–3.3V
Charge cutoff voltage (V/cell)	2.40 Float 2.25	Full charge detection by voltage signature		4.20 typical Some go to higher V		3.60
Discharge cutoff voltage (V/cell, 1C)	1.75V	1.00V		2.50–3.00V		2.50V
Peak load current Best result	5C[8] 0.2C	20C 1C	5C 0.5C	2C <1C	>30C <10C	>30C <10C
Charge temperature	–20 to 50°C (–4 to 122°F)	0 to 45°C (32 to 113°F)		0 to 45°C[9] (32 to 113°F)		
Discharge temperature	–20 to 50°C (–4 to °F)	–20 to 65°C (–4 to 49°F)		–20 to 60°C (–4 to 140°F)		
Maintenance requirement	3–6 months[10] (toping chg.)	Full discharge every 90 days when in full use		Maintenance-free		
Safety requirements	Thermally stable	Thermally stable, fuse protection		Protection circuit mandatory[11]		
In use since	Late 1800s	1950	1990	1991	1996	1999
Toxicity	Very high	Very high	Low	Low		
Coulombic efficiency[12]	~90%	~70% slow charge ~90% fast charge		99%		
Cost	Low	Moderate		High[13]		

Battery Charging Terminology

- **C-rate:**
  - The capacity of a battery is commonly rated at 1C, meaning a fully charged battery rated at 1Ah should provide 1A for one hour. 1C charge rate means charging at a current equal to the battery's capacity rating in Amp*hours
- **CC/CV:**
  - Constant Current / Constant Voltage charging method - used for most battery chemistries
- **Termination:**
  - Continuous charging of many chemistries shortens battery life (or worse…). Criteria for terminating a charge cycle depends on Battery chemistry:
    - C/x charge current reduction
    - Safety timer
    - dV/dt (Rate of Change in Bat Voltage)
    - dT/dt (Rate of Change of Bat Temperature)
- **Precharge:**
  - Trickle charge depleted batteries until VBAT exceeds minimum threshold
- **Recharge:**
  - Initiate new charge cycle when VBAT drops below recharge threshold
  - Compensate for self-discharge

Charge Cycle Examples





锂电池举例

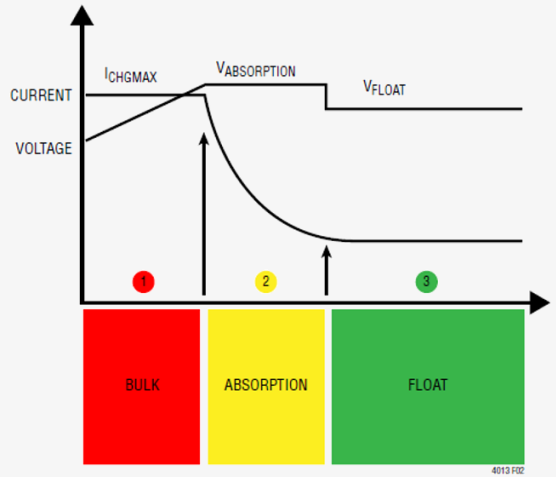


Figure 2. 3-Stage Charge Cycle

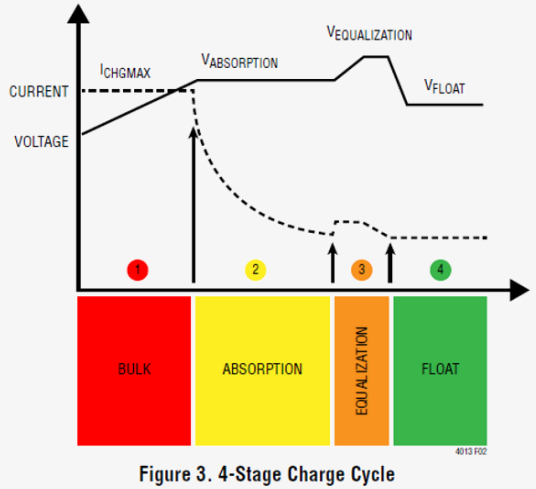
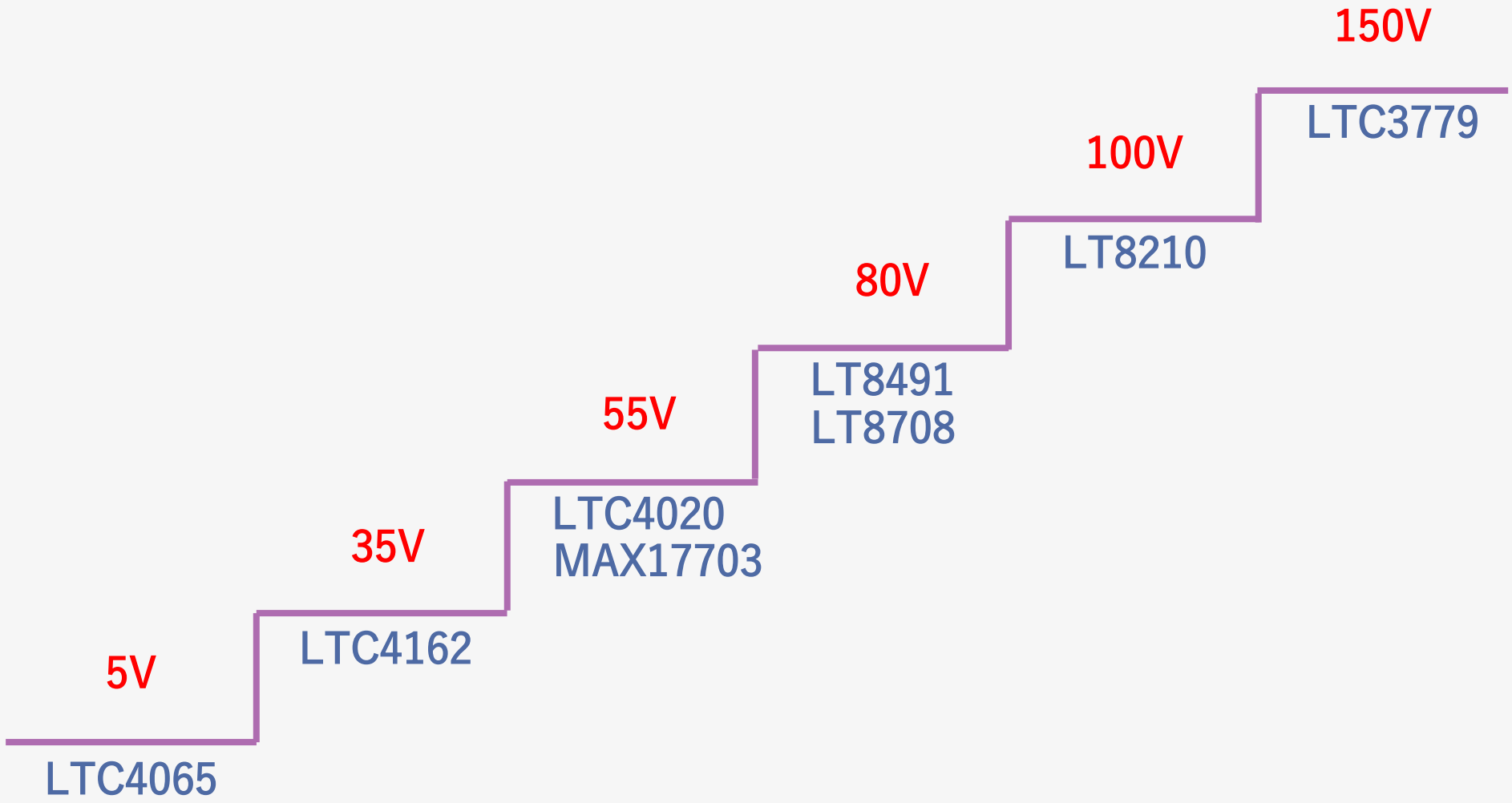


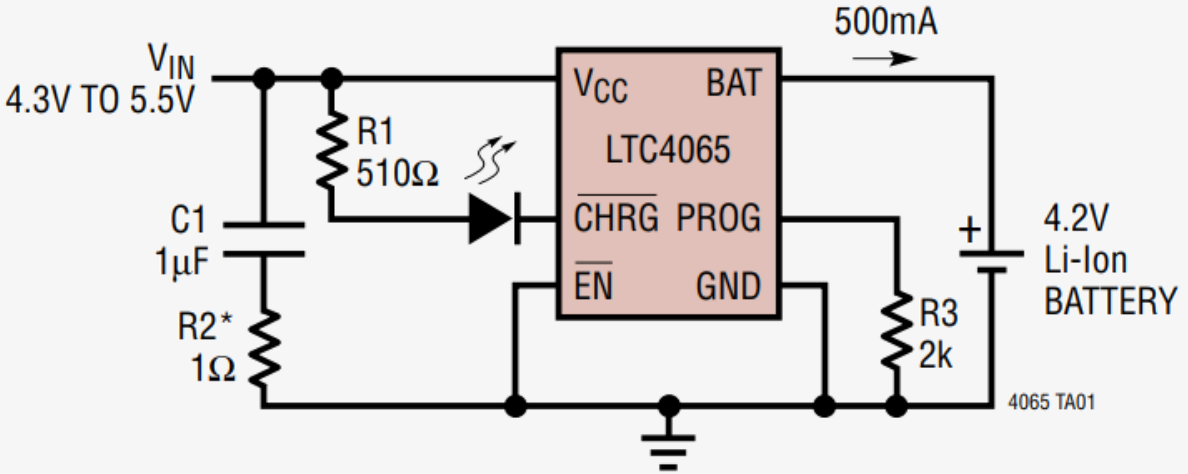
Figure 3. 4-Stage Charge Cycle

铅酸电池举例

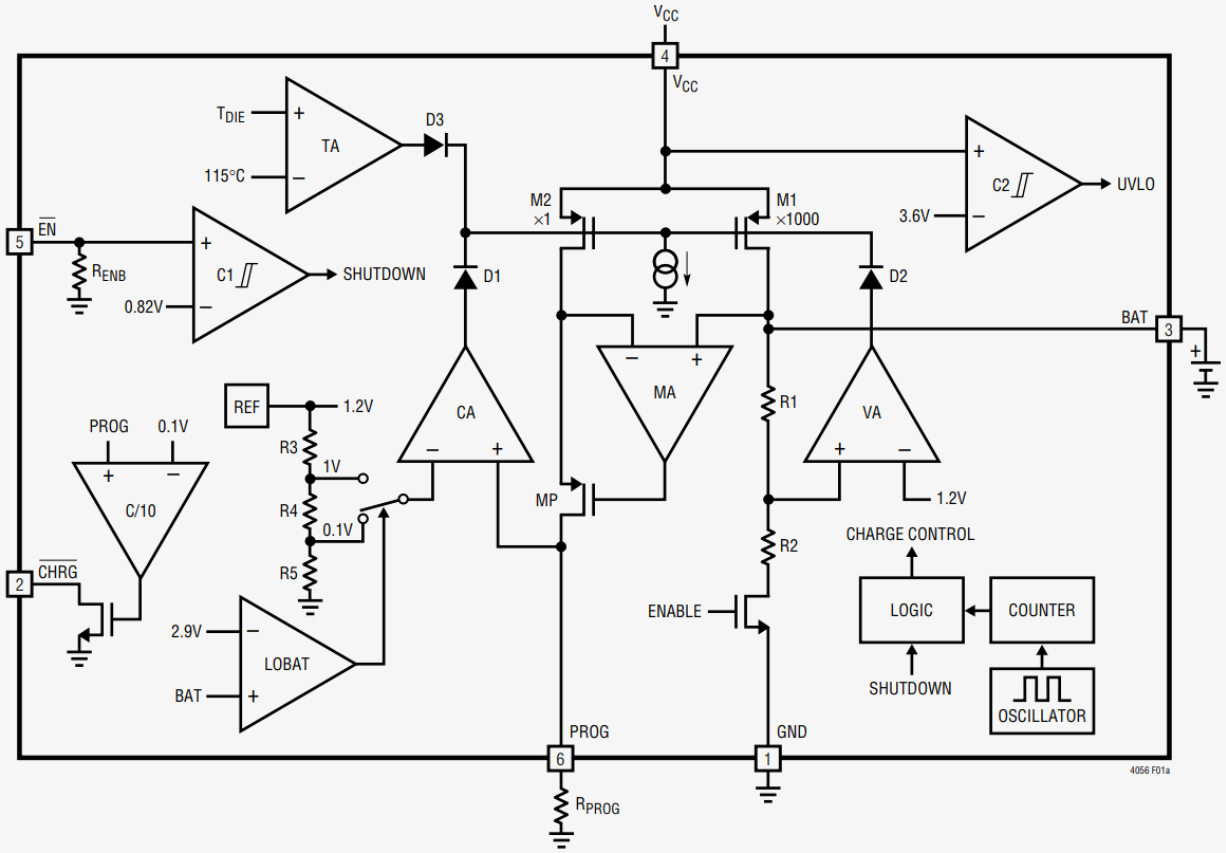
Agenda



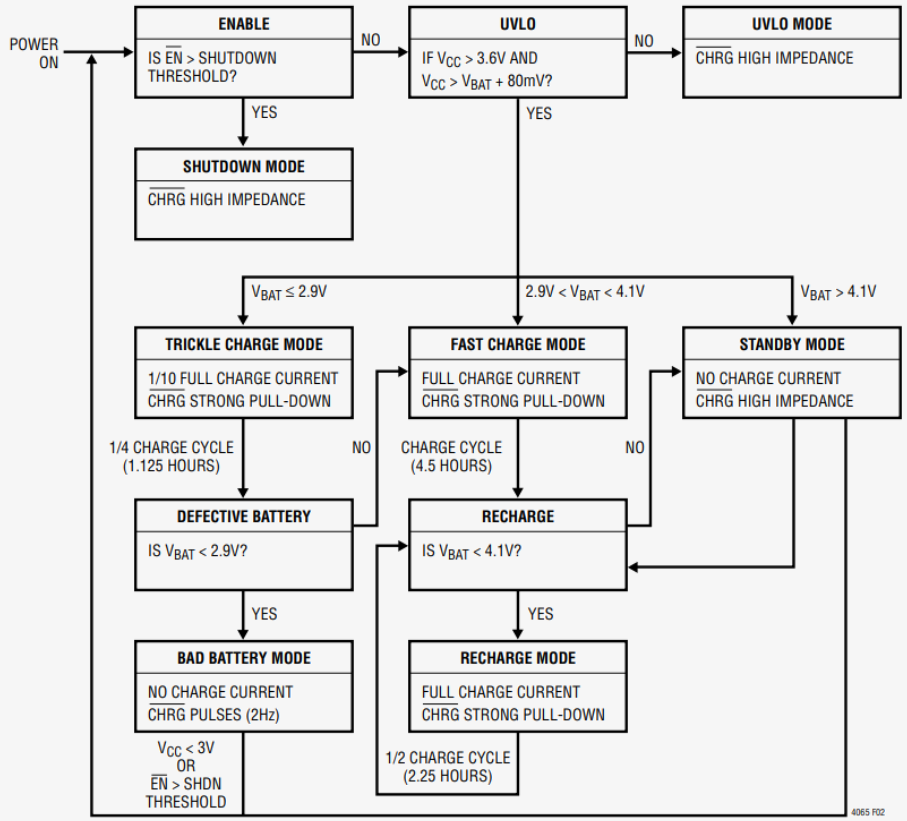
LTC4065 1S Linear Charger



LTC4065 1S Linear Charger

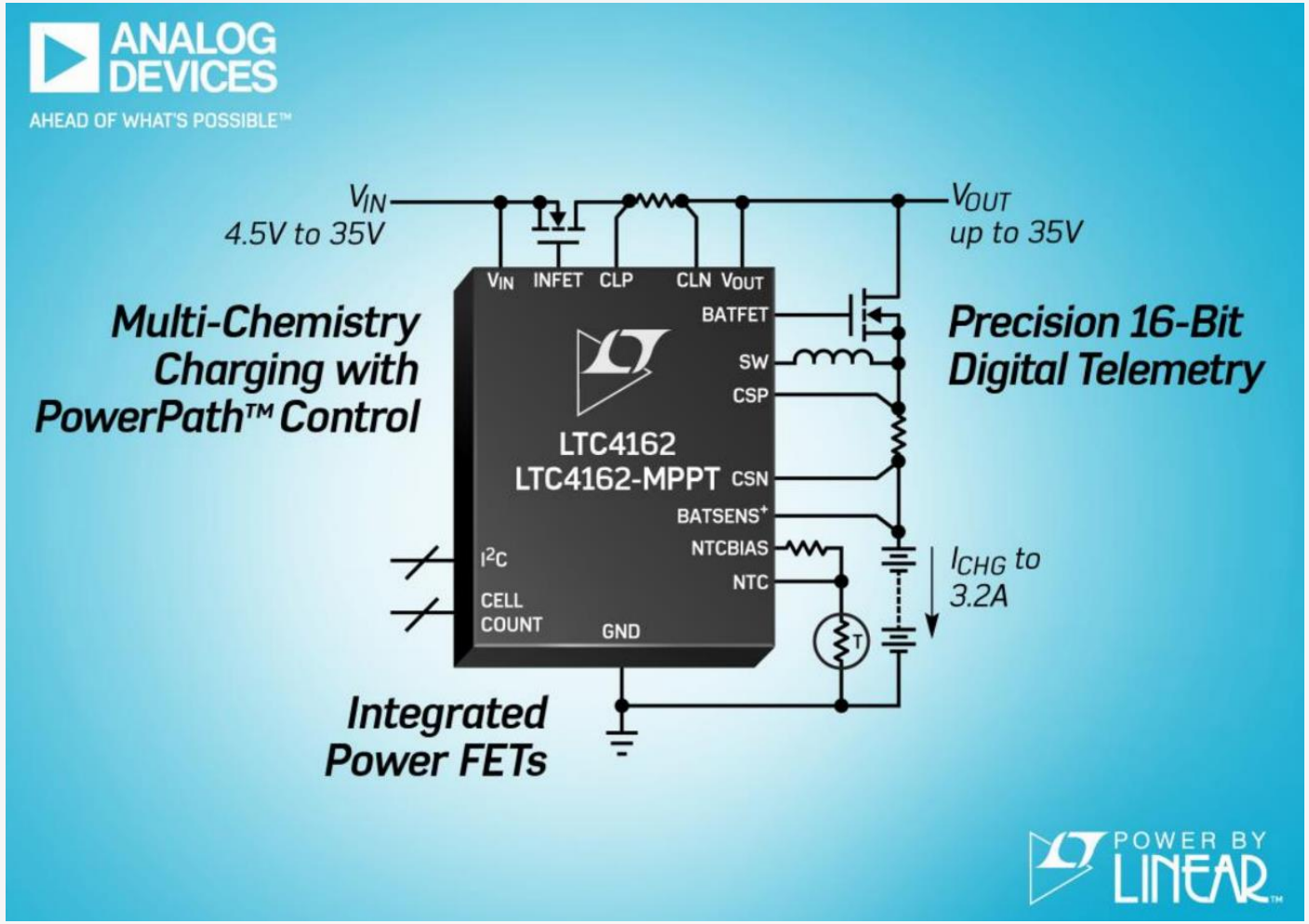


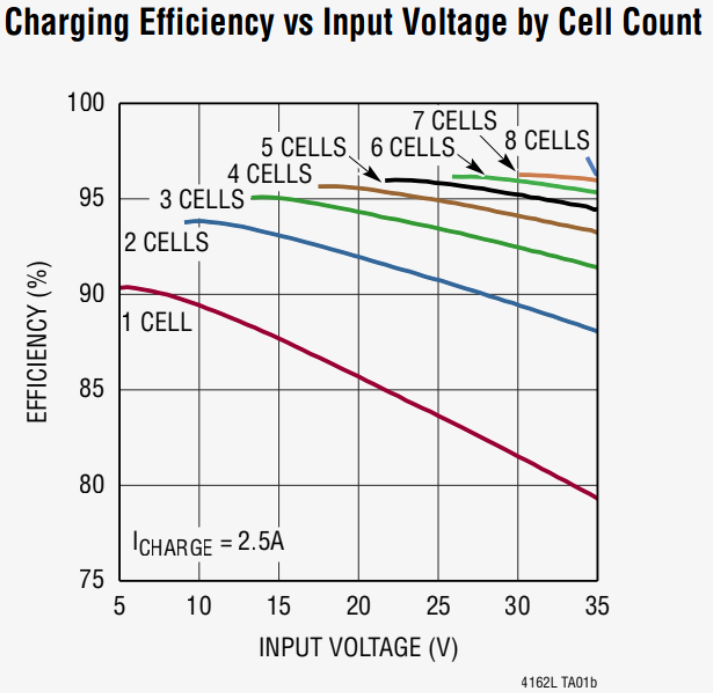
内部结构



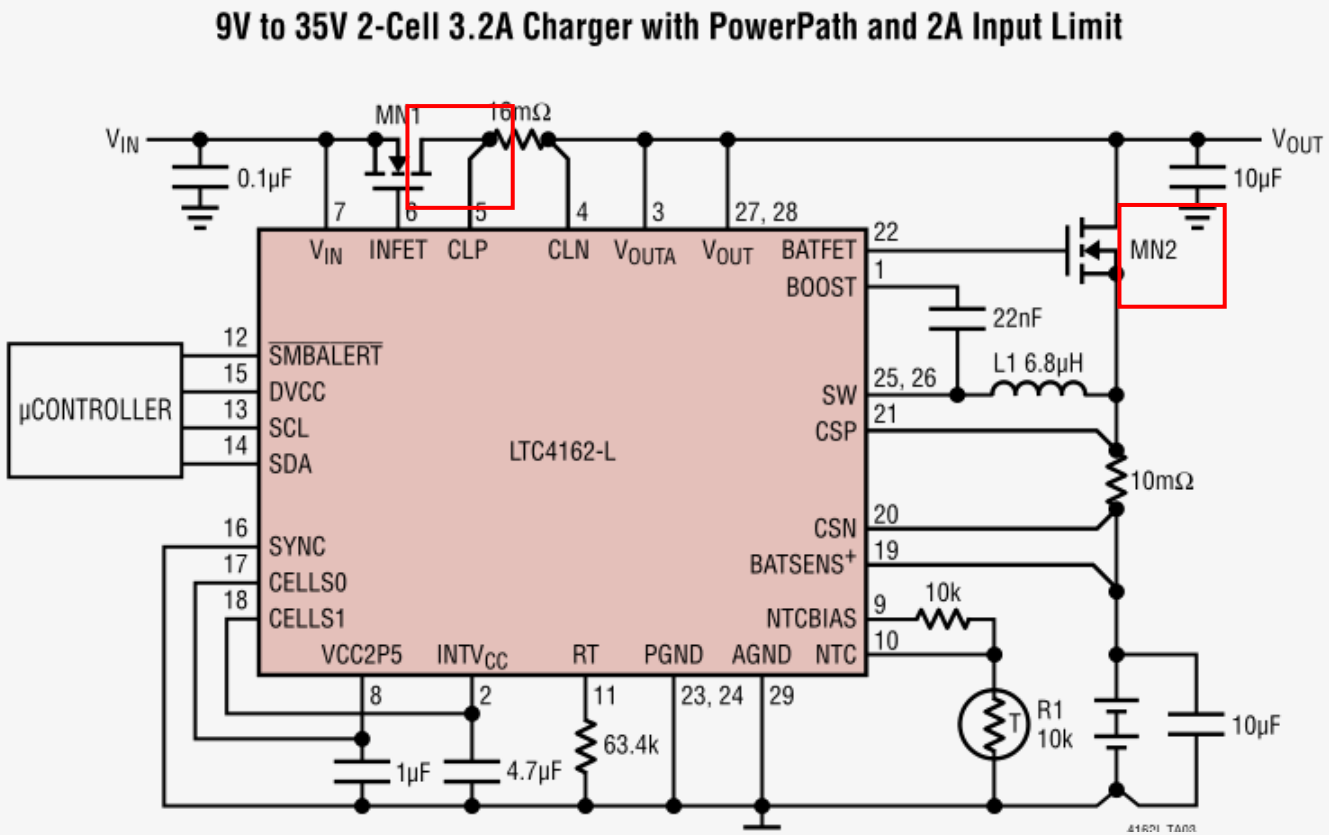
充电算法

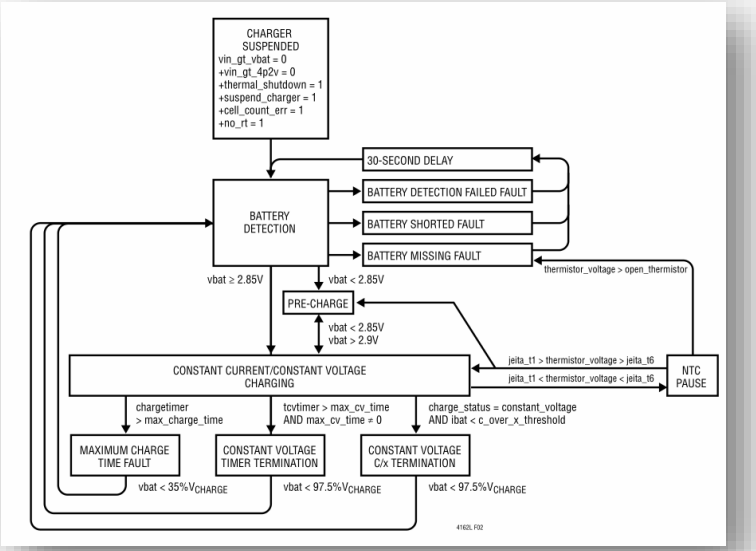
LTC4162 35V buck ---- PowerPath + IIC + MPPT



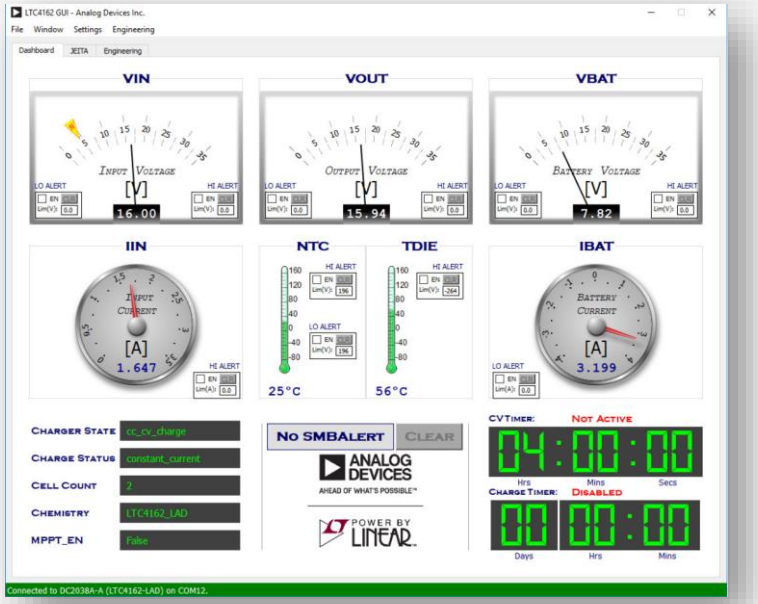


LTC4162 35V buck ---- PowerPath + IIC + MPPT



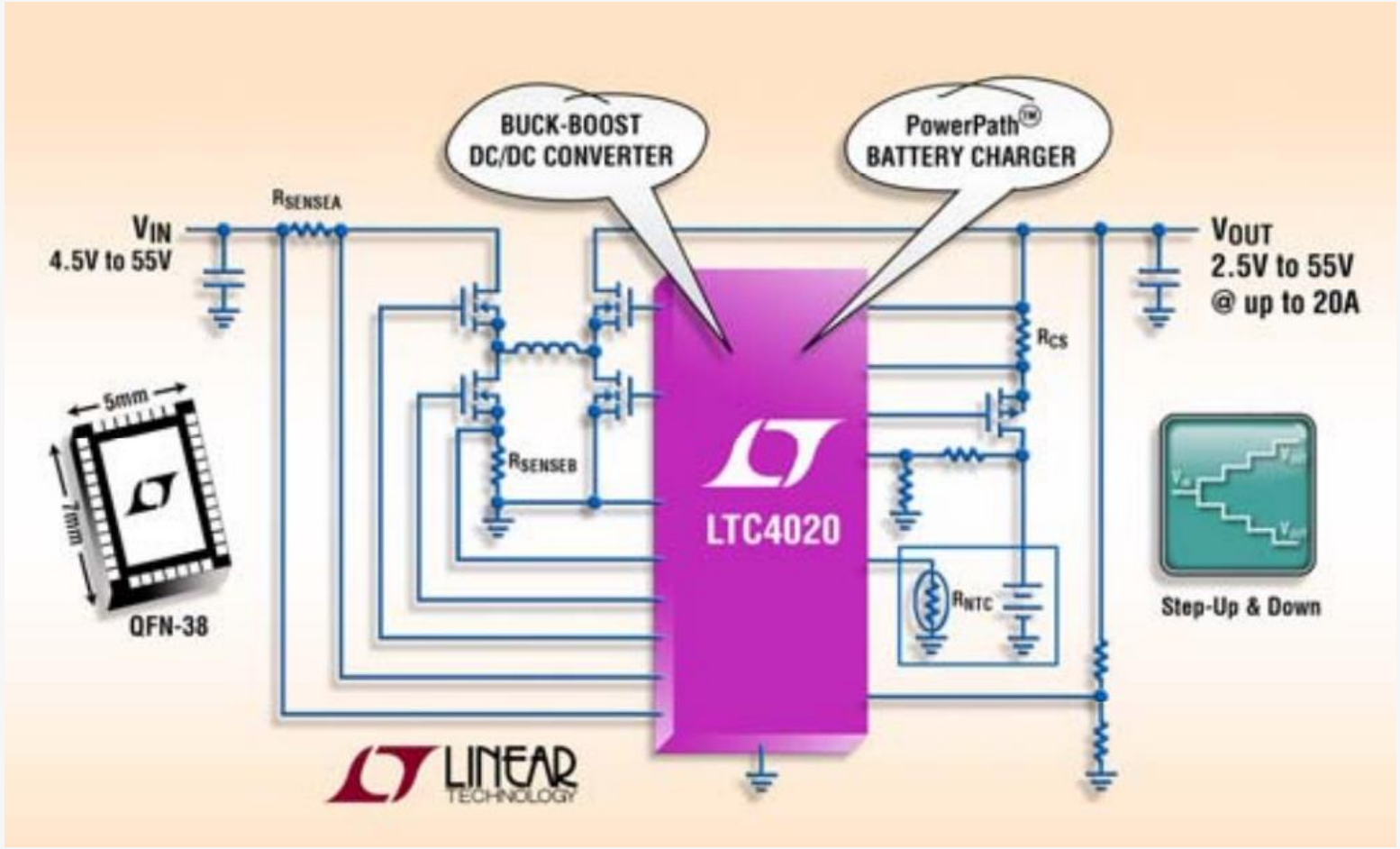


充电算法

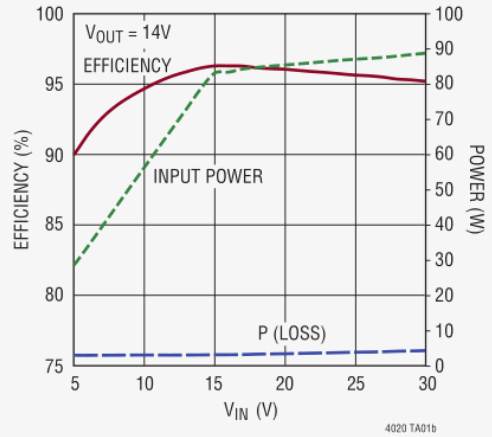


全参数监控

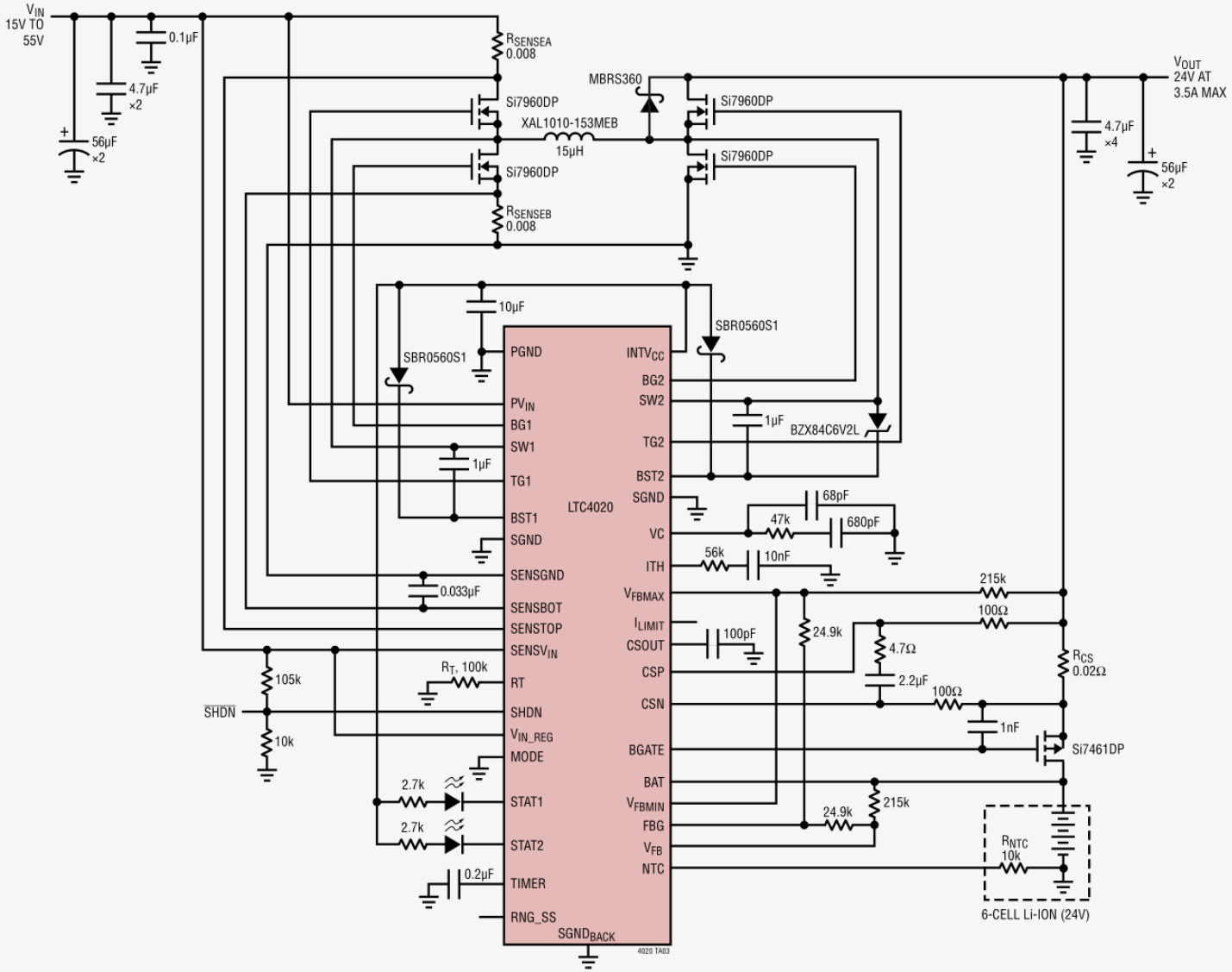
LTC4020 55V buck-boost ---- PowerPath + ChargeControl

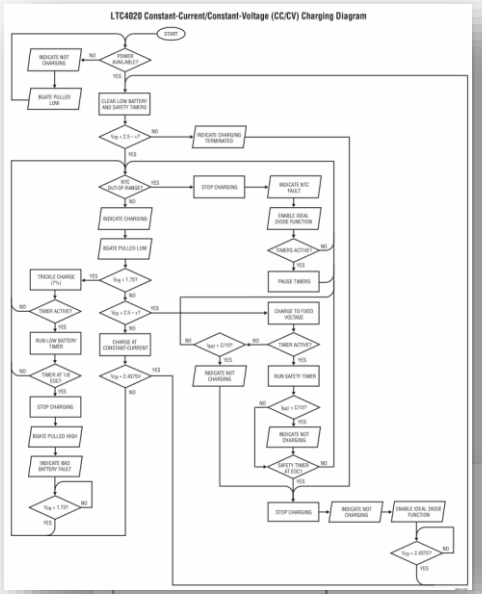


5V to 30V 6-Cell Lead-Acid Supply/Charger
Maximum Power Efficiency vs V_{IN}
(Application Circuit on Page 37)

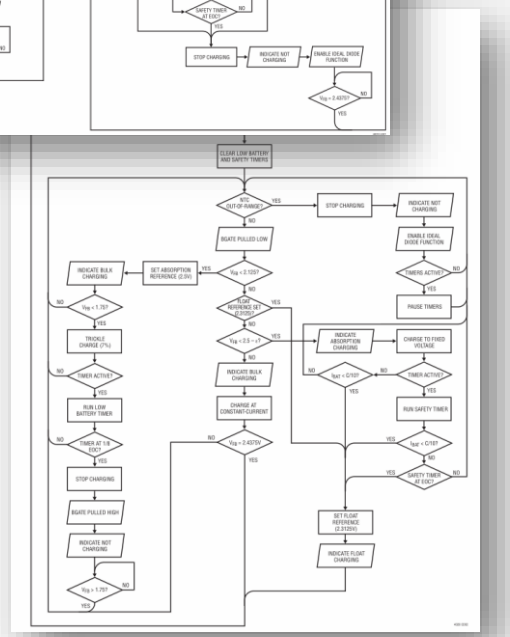


LTC4020 55V buck-boost ---- PowerPath + ChargeControl



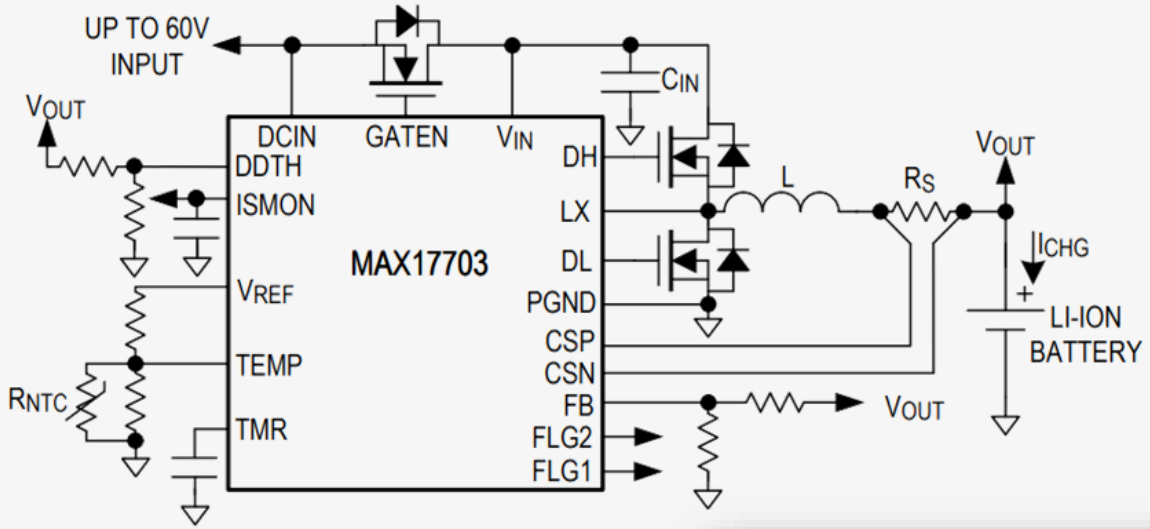


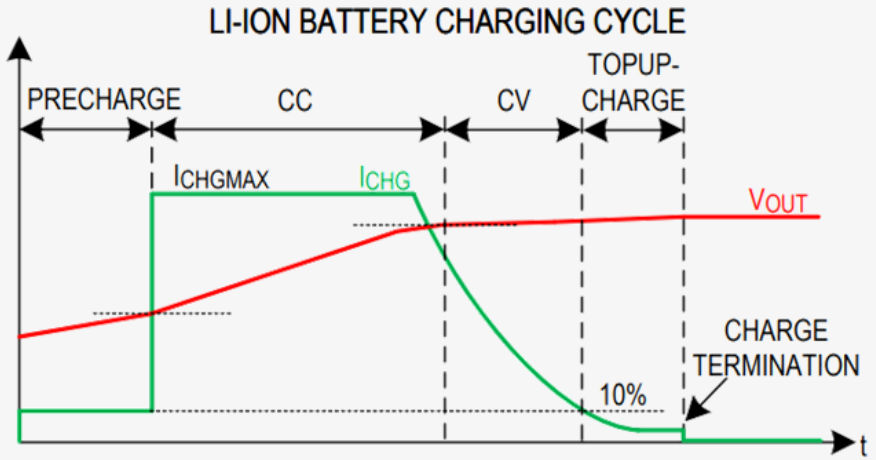
CC/CV 充电算法

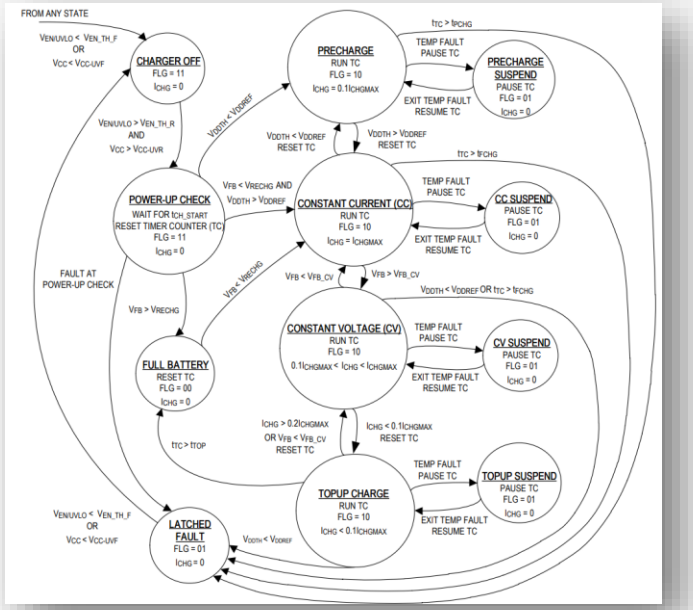


铅酸充电算法

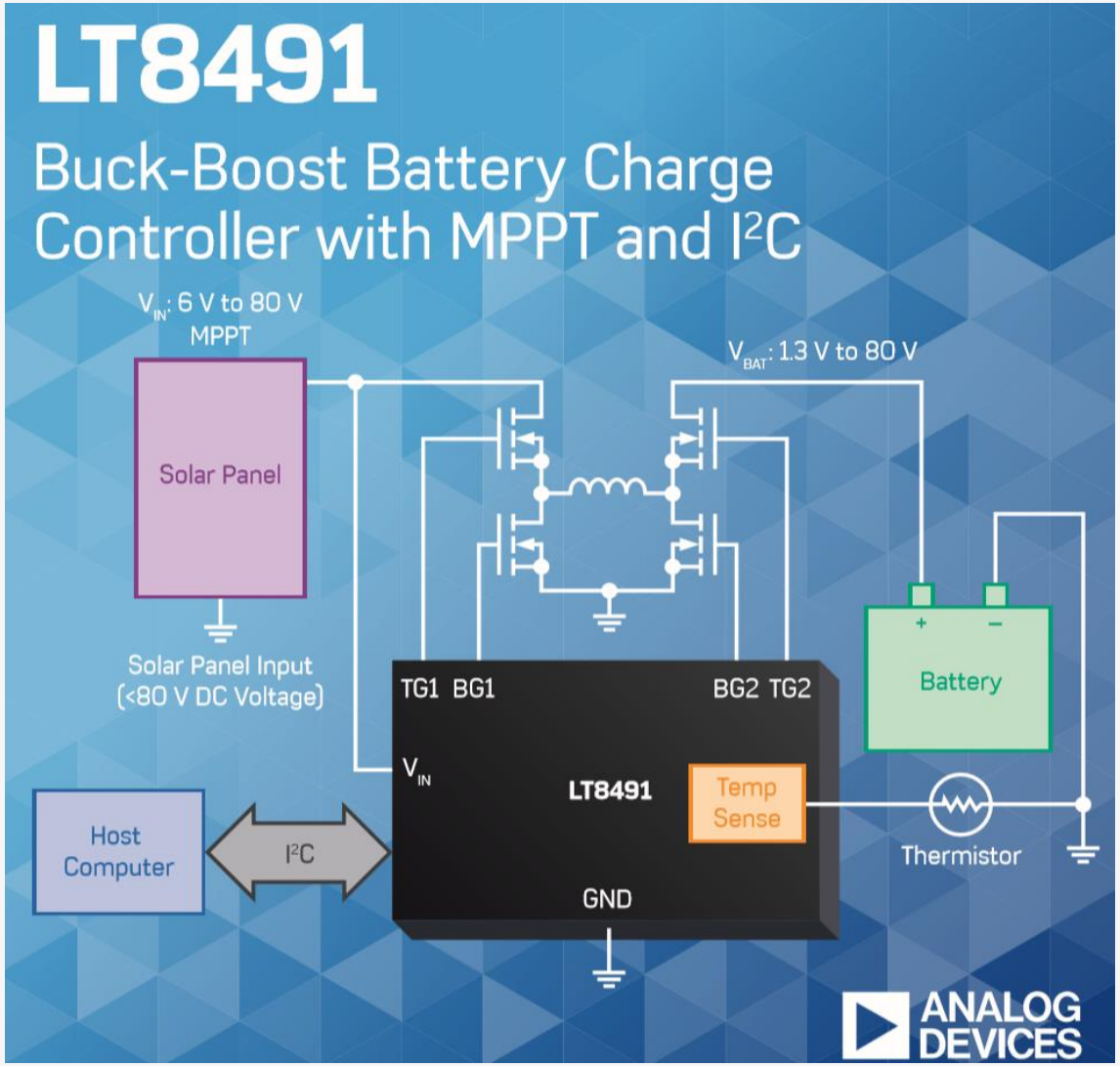
MAX17703 60V buck ---- Cost-Effective



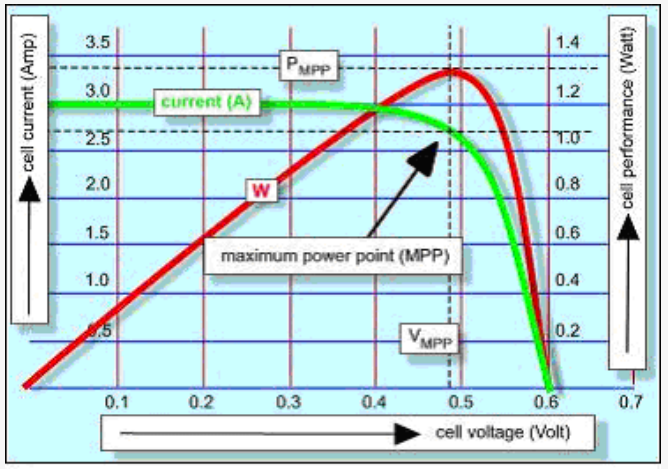




LT8491 80V buck-boost ---- MPPT + IIC

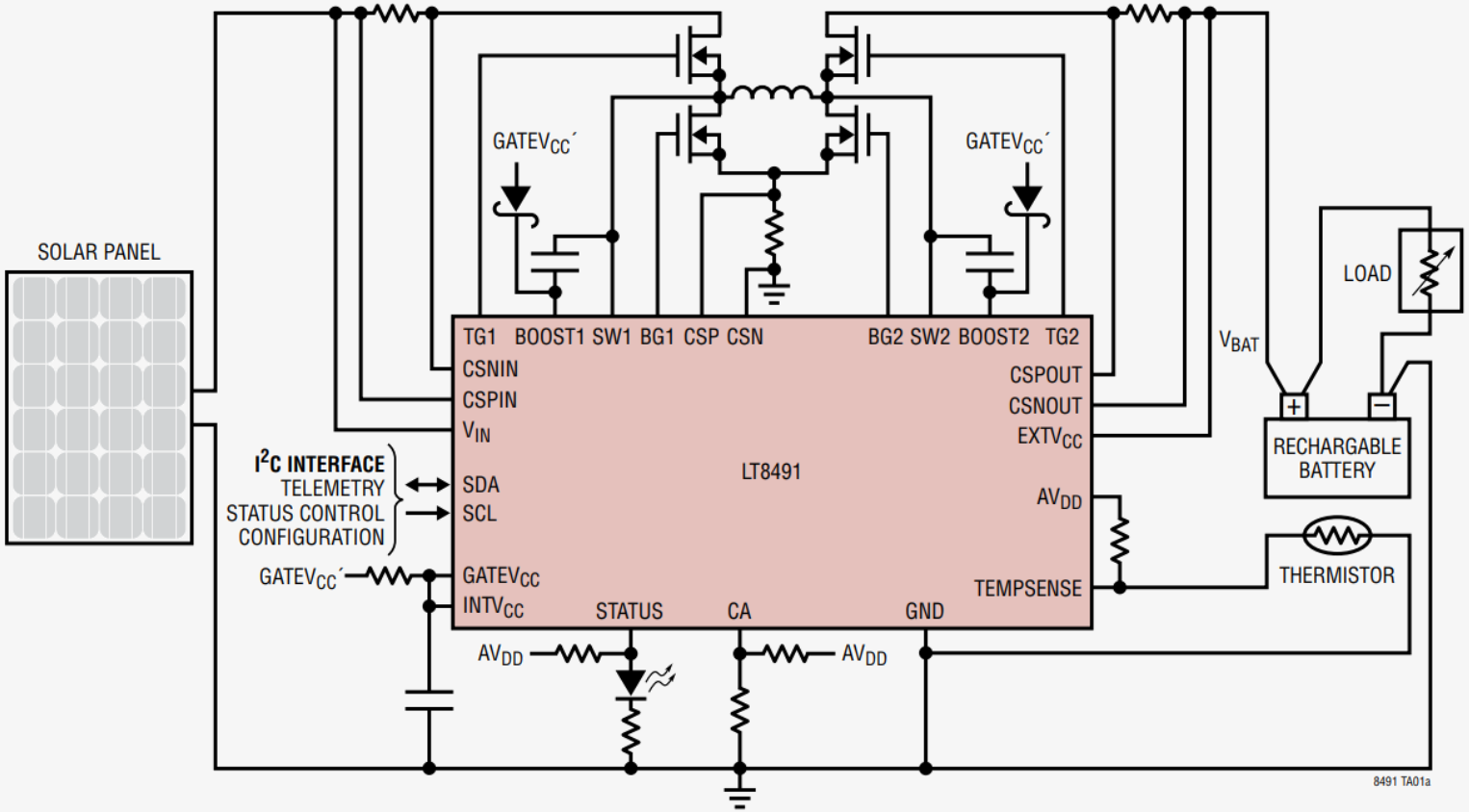


MPPT Technology

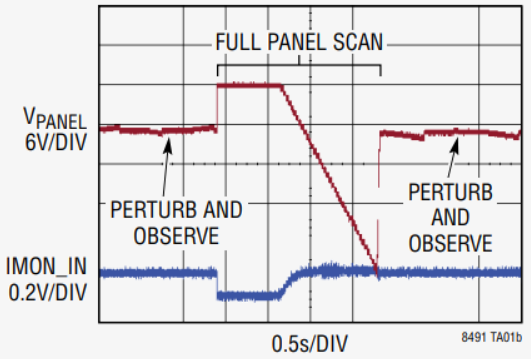


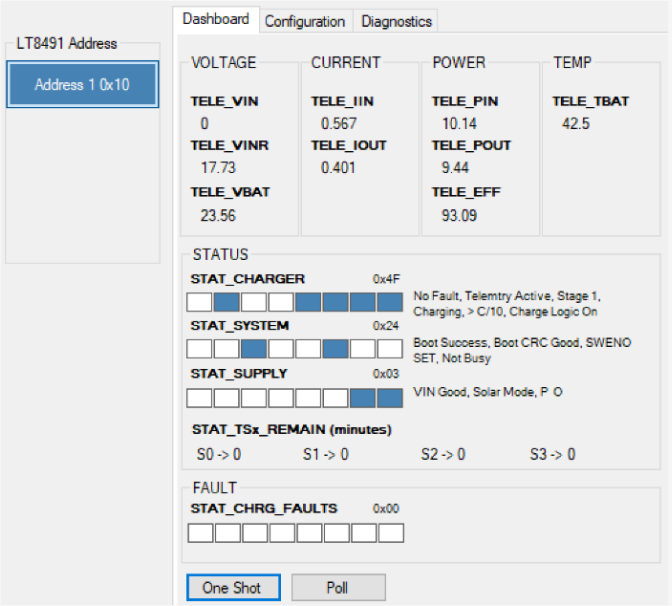
LT8491 80V buck-boost ---- MPPT + IIC

Simplified Solar Powered Battery Charger Schematic



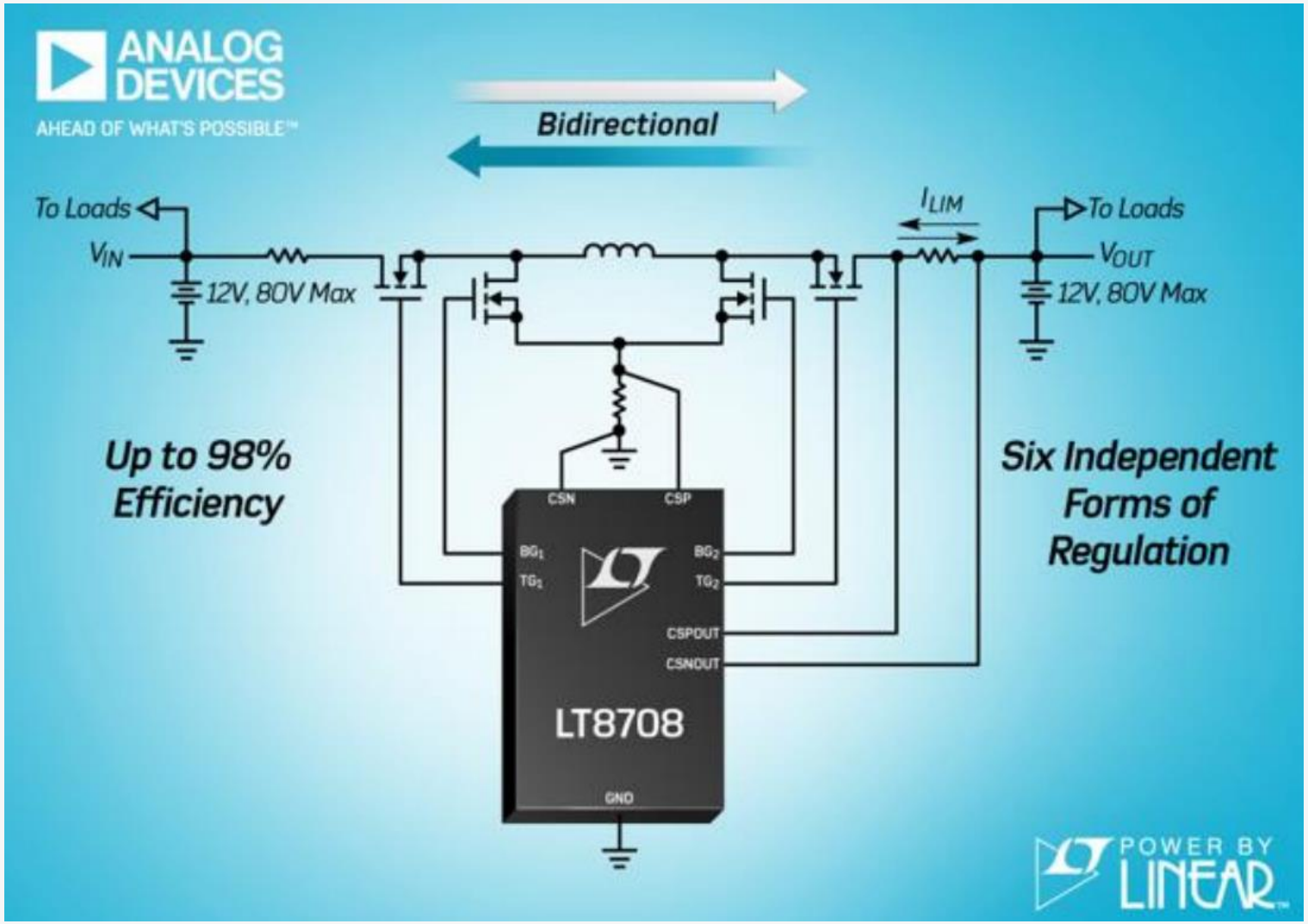
Maximum Power Point Tracking

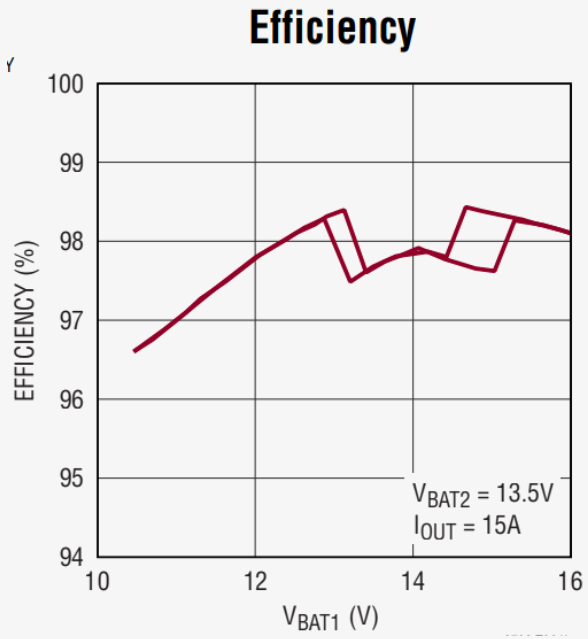




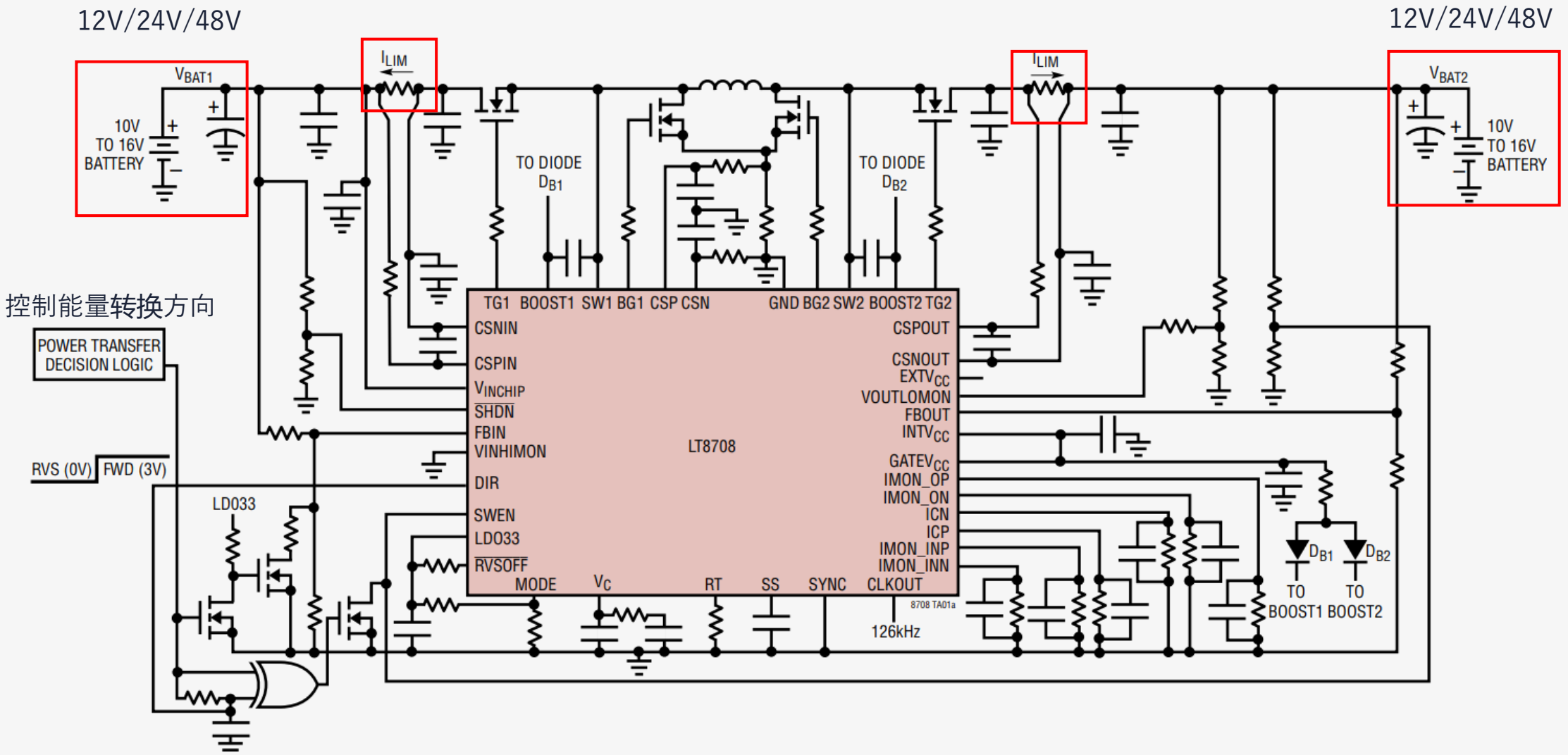
全参数监控

LT8708 80V buck-boost ---- Bidirectional

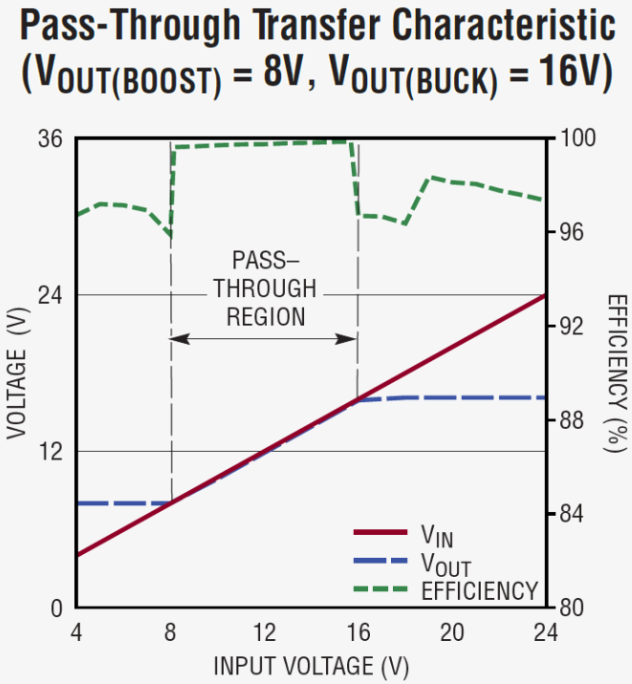




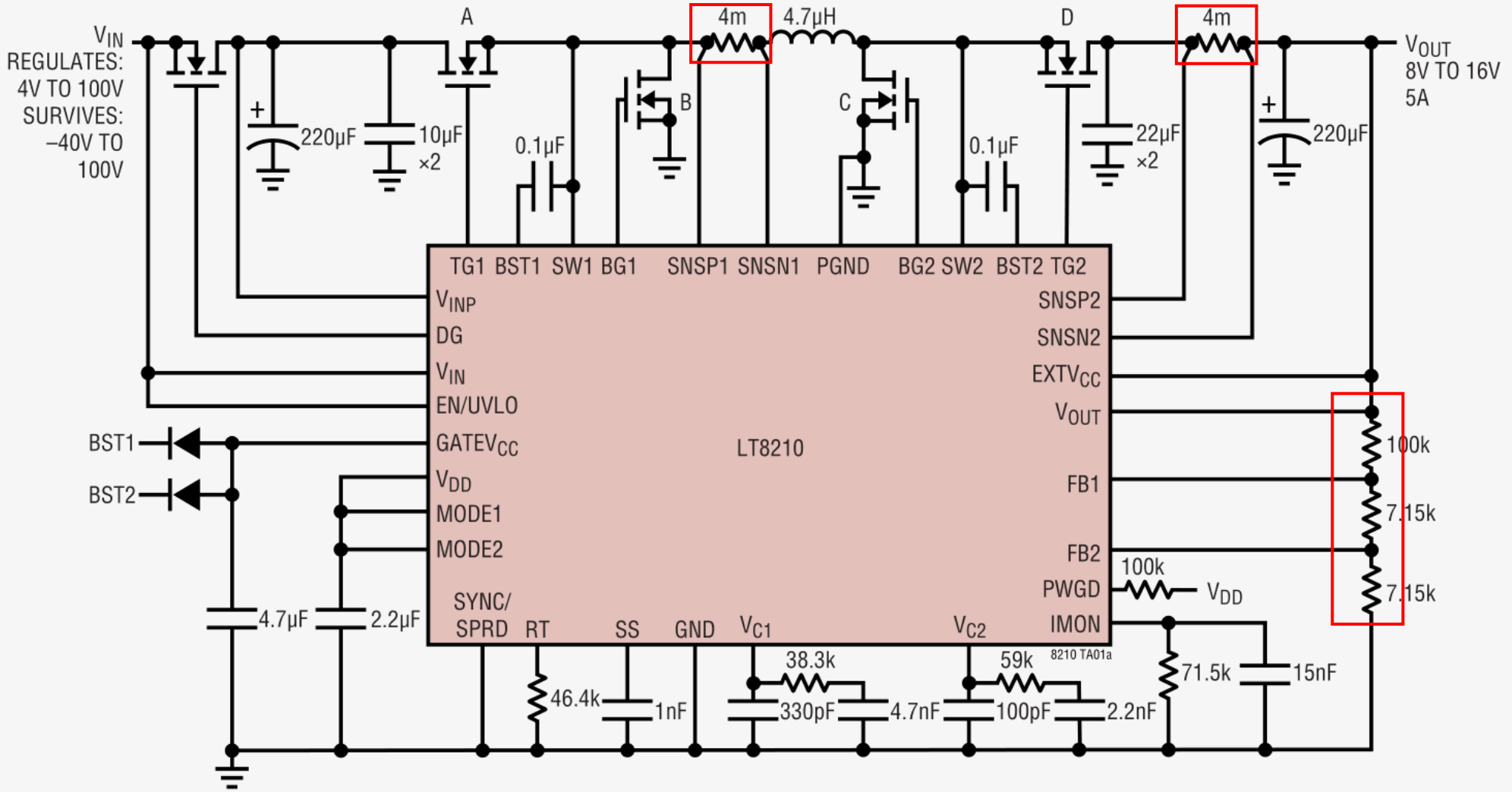
LT8708 80V buck-boost ---- Bidirectional



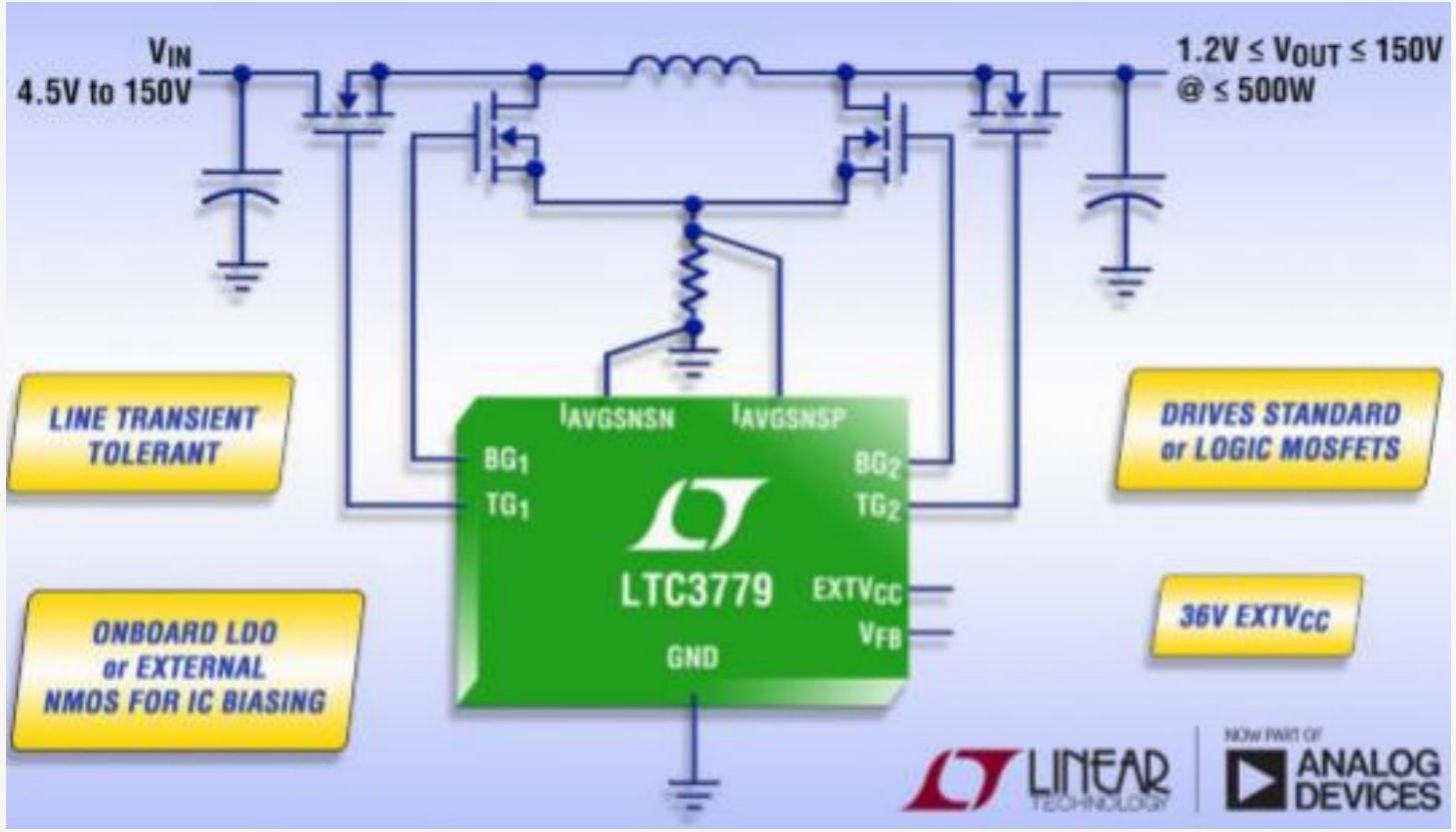
LT8210 100V buck-boost ---- Pass-Thru

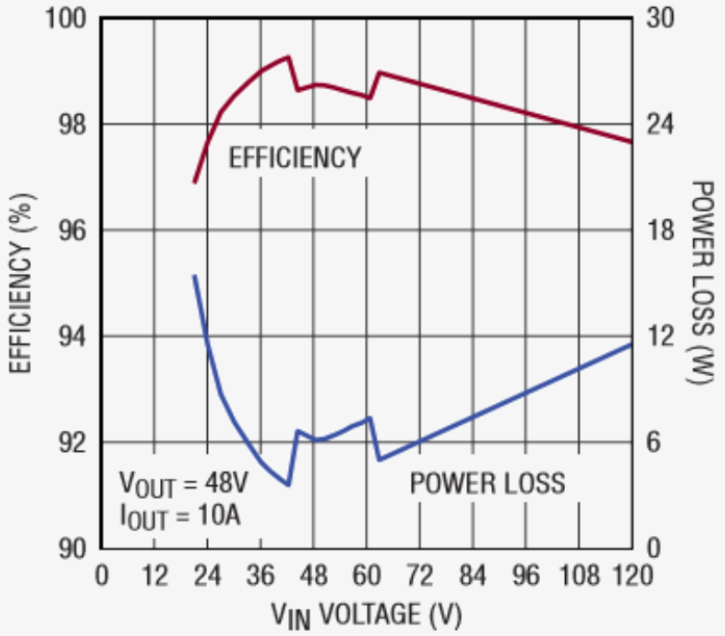


LT8210 100V buck-boost ---- Pass-Thru

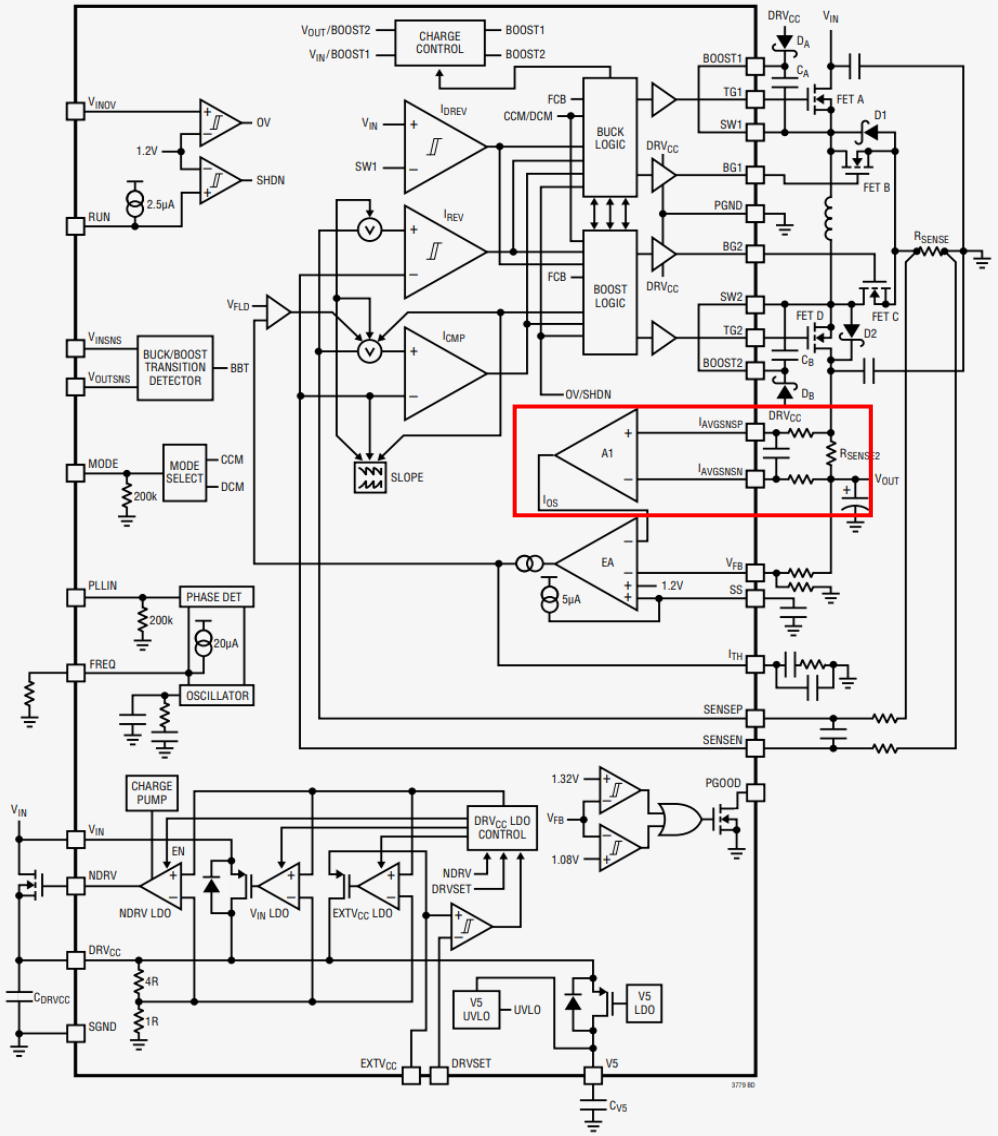


LTC3779 150V buck-boost





LTC3779 150V buck-boost



输出恒流控制——（电池充电CC模式）

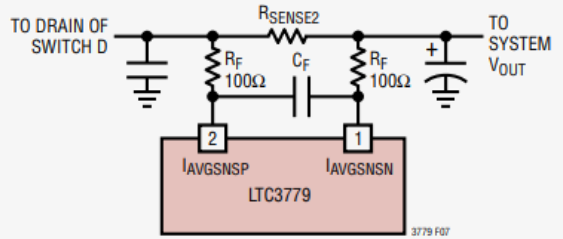


Figure 7. Programming Output Current Limit

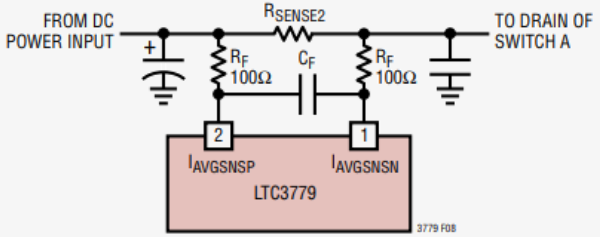
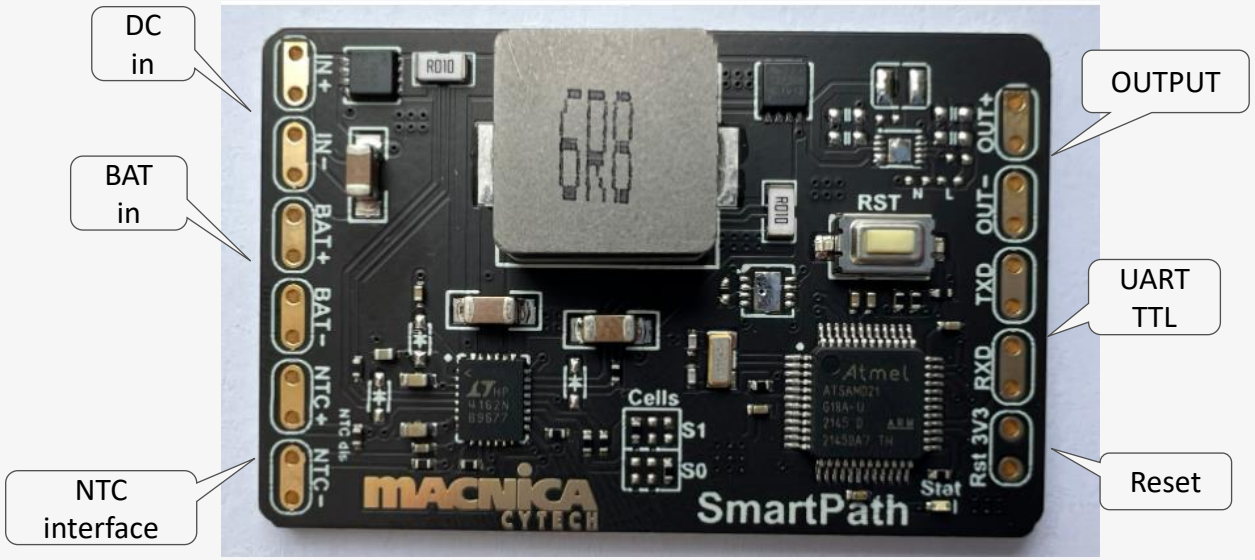


Figure 8. Programming Input Current Limit

输入恒流控制

DEMO (Module product) shows ---- LTC4162 / LTC4020



LTC4162

LTC4020

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